the slightest doubt but that they may be all brought to habits of industry and civilization, when the mode of obtaining potatoes and wheat . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

country is generally . . open, flat, champaign country, with abundance of verdure, and well watered. It far exceeds my expectations, although I was prepared to expect something very superior. I consider the representations of Mr. Batman fully borne out, and from the account given by Buckley, I am disposed to believe . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . I this day . .

settlement at Port Phillip, having taken a trip over in the "Adelaide" with some of my sheep; I found the young woman before spoken of living at the settlement with her husband and his other wives. She had quite recovered from the contusion, and her husband was again reconciled to her.*

ART. X. — *Remarks on a Tertiary Deposit in South Australia.* By the REV. JULIAN EDMUND WOODS, Penola, South Australia.

[Read before the Institute, 29th September, 1858.]

I PROPOSE in this paper to describe briefly to the Institute a tertiary formation, which is only interesting inasmuch as it furnishes clear evidence of immense changes occurring in this continent during the tertiary epoch. I have chosen it as a subject for the facility of its description, and because its leading features can be done justice to within moderate limits. There are no fossils to be described, nor any difficult arrange-

* The Editor hopes that the thread of the narrative will be pursued, notwithstanding the many spaces that exist. Each space represents the proportionate amount of text wanting.—J. M., ED.

ment of rocks requisite. I have merely to give a few plain facts, patent to the most superficial observer, and to draw very intelligible inferences from them. If the paper should appear incomplete, it is because I wish to do no more than allude to details, the knowledge of which more competent men may hereafter extend.

The few fossiliferous rocks that South Australia possesses, are all, with one exception, of the tertiary epoch. That one exception is at Willunga, where the formation is clearly silurian. None of the tertiary beds have been as yet described, but their classification will not, I apprehend, be a matter of much difficulty. As they are connected with my subject, I will here indicate where they occur, as far as the colony is at present known, beginning with the most recent. All round the coast from Adelaide to Port Augusta, and from the Coorong to the mouth of the Glenelg, shells of existing species are found, loosely imbedded in sand or mud to some distance above the sea level. Where the country is flat (as near Guichen Bay), this is continued sometimes seventeen miles from the shore. The sea has left this most recent formation as the land has been slowly upheaved. Where the deposit goes to any depth, the same shells are found imbedded in limestone, and what would be thought a different bed, is shown by the included fossils to be of the same geological age. Immediately under this, at Adelaide, another very recent bed, containing shells, is found. The inclosed *testacea* are all species now existing near Adelaide, or on the adjacent coast in a more northerly direction. They generally show a more genial climate than that which obtains at present, but as the deposit is a very small one, this difference may be owing more to local circumstances than to any great variation of the physical geography of the locality. Next to this again, and immediately following, as far as I can ascertain, though my researches are not sufficiently extensive to assert that no other deposit intervenes, there occurs a quartzose limestone-bed, whose extensive cross or diagonal stratification shows it to have been deposited from a deep sea current. This contains no fossils, at least such as can with certainty be determined. The next beds in succession, and the last as far as we know, are the Mount Gambier deposits, which contain shells, mostly of extinct species. It is not quite certain whether these latter should be called upper Eocene or lower Miocene, but more extended investigation will, doubtless, prove them to belong to the former. I say this because I have

found fossils which properly belong to the London clay, and it would be difficult to imagine uncommon shells having so wide a range as the lower Eocene in England, and the lower Miocene in Australia. I have in the list of tertiary rocks just detailed, omitted those beds which are found on the banks of the Murray, particularly at the north-west bend. I have never had an opportunity of examining these deposits, but from specimens forwarded to me I think they are contemporaneous with the Mount Gambier limestones. There is a great variety of *nautilidæ, terebratulæ* and *pyrulæ* of extraordinary size. I have also seen one specimen of the *plagiostoma spinosum* of the same species as that which occurs in the chalk at home. More extensive data will enable future enquirers to determine the precise position of these strata, and I am sure they will well repay the trouble of any one who shall investigate them hereafter.

The deposits I wish to call attention to on this occasion are those already described as owing their origin to deposition from a deep sea current. They are found from Lacepede Bay, (as far as I have ascertained) to Rivoli Bay. Patches also occur at Mount Gambier, and at some places near the mouth of the Glenelg. Where they are seen most to advantage is, however, at Guichen Bay; and it is to observations made in that locality, I shall confine myself more immediately. The whole eastern and northern sides of Guichen Bay are composed of low sand-hills, scarcely rising thirty feet above the water level; but on the southern side quite a change takes place. The sand is replaced by rough, craggy rocks, which, though not rising very high, are bold and abrupt, sometimes presenting a perpendicular face to the heavy surge which beats upon that coast. Seen at a distance, one would imagine that these rocks were divided into huge strata, fourteen or sixteen feet thick, but on a closer inspection, another, though less distinct kind of stratification is discernible. In addition to the great divisions (which are so distinct as almost to lead one to suppose that three or four huge slabs of stone were laid upon one another,) there is cross stratification. This is a lamination which divides the beds into strata about two inches thick, but they are never horizontal, like the great divisions, are seldom parallel to each other, and never continuous across the divisions spoken of above. Now all these appearances, taken in connection with the mineral composition which I shall just now describe, are clearly indicative of deposition from an ocean current. I need not go through all

the reasons which make this conclusion apparent. It will be sufficient to say that the want of horizontality in the smaller strata is due to the force of the current, and the greater divisions are caused by an alteration in the direction of the stream, which, before it would deposit any new matter, would carry away the lighter superficial particles, and wear down to a smooth surface all inequalities. The material of the rock would appear, at first sight, to be a coarse-grained sandstone. I should call it a calcareous sandstone. Under the microscope it is found to consist of small particles of shells, worn by attrition into thin scales and small grains of quartzose sand. It is freely acted upon by weak acids, and on a qualitative analysis showed a large proportion of silica, lime and magnesia (carbonates), with small proportions of sesquioxide of iron and sulphate of lime, but no appreciable quantity of phosphates nor organic matter. It would not be difficult to show that the formation was deposed in deep water, perhaps at some considerable distance from the coast; for anything but a slow-moving large body of water out of the influence of land would certainly carry down larger fragments of shells than what are here seen. From the great attrition the particles have been subjected to, one can gather that they were carried a long distance. The place where the deposit is seen to best advantage is in a small bay on the southern side of Cape Lannes, which with its projecting reef forms the termination of Guichen Bay on the south. Here the rocks are seen in bold sections, over fifty feet in thickness. This little bay is very deep, so that the water washes the foot of the cliffs nearly all round. In some places the wearing of the surf has undermined the cliffs and caused them to fall in, or the spray has eaten into their soft, friable texture, giving them a wild jagged outline. These features, united with irregular cross stratification, the dark hue of the stone, the heaps of ruins which are scattered about, and the boiling of the surf as it breaks heavily against the rocks, even on the calmest day, would make a grand and sublime scene, were it on a somewhat larger scale. However, even as it is, it is wild and desolate, and the little verdure which the Mesembryanthemum give as they creep down the surface of the rock, or hang swaying in the wind, tends little to soften the savage aspect of the place. There are, as I have before stated, no fossils, but the summit of each cliff is topped by a stratum of compact limestone, horizontally deposed, and lying unconformably. This, I presume, is the relic of the last coast action

before the deposits were upheaved to their present position; and from the fact that the same stone, lying in the same manner further inland, contains fossils of existing species, I have little doubt that it is of the same age as the very recent beds spoken of before, as existing all round the coast.

The current from which the deposits under consideration arose must have been of very wide extent, and have deposited its sediment very equally, because the upheaval which has raised the land portion, has given rise to rocks of the same height all along the shore, sometimes at a considerable distance from it. Thus there is an archipelago of small rocks encircling Guichen Bay, which rise out of the sea like patches of table land, and a reef called Cape Jaffa Reef is a chain of such flat-topped rocks, which run twelve miles out to sea. I have said that the stone is soft and friable, and that the sea easily corrodes it away. Many singular instances of this decomposition are perceptible. At a small distance from Cape Lannes there is a narrow strip of tubular rock, narrower at the middle than at the ends. The surf has undermined the centre part, so that a natural bridge of stone, supported by two buttresses, is now the result. Again, the constant action of water has made deep caves at the bottom of some of the cliffs, and in some instances the beating water has bored a sort of chimney up to the surface, giving rise to the well-known blow holes. One of these is pretty large, and when the tide is high, and a heavy swell on, the spray is dashed to a considerable height out of the dry rock, with a roar that may be heard a long way off. But there is, perhaps, no more singular effect visible than that which is caused by the action of the spray in those rocks most exposed to its influence. The tops of such are covered with pinnacles as delicate and varied in form as reef coral. A mere description could scarcely do justice to the strange appearance they present. It seems at first sight as if the rocks were covered with slender stone shrubs, tapering gradually to a point, or as if the roof of a cave, studded with stalactites, were turned upside down and placed on the sea coast. Anything but spray must have long ago broken them to pieces, and even then, how they have been spared, while the surrounding rock has been worn away, does not appear very plain. It would appear to me that they must be the result of concretions of the lime and sand, caused by the percolating of water through the beds prior to upheaval. This would, and did in fact, in other places harden certain portions, and enable them

better to resist the wear of water. Instances of this concretion are very common where the action of the spray has not destroyed the surrounding matrix. At one cliff out of reach of the sea, where portions of the rock have fallen away, concretions are very numerous. The sides of the rock are covered with them running through the strata like roots, or hanging down from the roof so as easily to be mistaken for stalactites, if they were not a little too crooked and irregular. Their appearance is just that of bent coral, about half an inch or more in diameter. The outside of these concretions is just like the rock itself, that is, are composed of small fragments agglutinated together; but on breaking them the inside is found to be hard and compact, like cherty limestone or dolomites. They are usually formed in concentric rings. I do not suppose that the action of the water in causing them has been merely mechanical. I suspect, from the large quantity of magnesia contained in them, that a doubly basic salt of carbonate of lime and magnesia is formed by chemical decomposition. Slow filtration of water might alone be a sufficient cause, because it is certainly from something of this kind that the layers of flint in the Mount Gambier limestones are chiefly owing. This is a department of geology where investigation is much required, for the "pot stones" in the chalk at home, which owe their origin to filtration of some kind, are by no means clearly accounted for. In addition to the corrosive action just described, the wearing of the strata by waves is very considerable, and thus we may see that the ocean is here indemnifying itself for the losses occasioned by the upheaval of the land. There can be no doubt that the sea will not be long destroying the beds within its reach, if the work of destruction proceeds as quickly as it has within a comparatively short space of time. We may, therefore, witness two phenomena not often associated together, namely, the land rising and the sea encroaching rapidly. It is interesting to observe how the sea soon replaces what it removes, and the seam of limestone which tops the rocks unconformably, answers the question which may be asked: what has become of the immense masses of rock which have been already destroyed? Such, for instance, as those portions which must have joined the coast with the rocky islands which fringe it. However, no conception of the great work of denudation which has taken place can be gathered from the comparatively small ravages in Guichen Bay. My belief is that the whole coast, perhaps as far as the mouth of

the Glenelg, and as far inland as Mount Gambier, has been covered with the same deep sea deposit now described, and it has afterwards been removed by coast action as the land slowly rose. My reasons for this opinion are founded on having noticed, at various parts of the country, little hillocks of rock, of small extent, and about fourteen feet in thickness, so identical in composition (even to the concretions) with the Guichen Bay formation, as to leave little doubt on my mind of their having been continuous with it. At Mount Gambier there is such a deposit. It is situated at a place called the Cave Station. Though rather more ferruginous, and containing occasionally rather larger fragments of shells, and sometimes even a whole oyster shell, there can be little doubt of its identity. It lies of course upon the limestones of Mount Gambier, where there is every reason to believe all the rest of the formation rests. The hillock now alluded to has formerly been studded with concretionary pinnacles, but of course much water worn, and barely jutting out from the surface. What with the hardening consequent on chemical action, and the ferruginous cement, the rock is almost as hard as granite, contrasting strongly with the soft white rock on which it rests. The hardness is doubtless the cause of its preservation. Another place where a patch is seen is at a station not far from the western bank of the mouth of the Glenelg. In this place (to which I regret I could only afford a passing examination) perfect shells are found, mostly species of *Astarte, Ostrea, Pecten,* and *Cardium.* The strata, though not apparently so thick, were quite as compact as those just mentioned. I noticed also above the cliffs at Portland a thin deposit of oyster shells. The colour and mineral structure of the rock in which they are, as seen from a short distance, seemed to me to be very like the same deposit, but I would hardly venture to say that it was really such. It is rather singular that it should rest upon a deposit which, if not identical with the Mount Gambier Eocene, is at least very close in succession. The *Spatangus Forbesii* occurs at both Portland and Mount Gambier, and many *Terebratulæ* and *Pectens* are identical; but the cellepora coral present in the latter has not as yet been found in the former. This latter fact may be due to local circumstances, and I have very little doubt that the beds will eventually be found to be contemporaneous.

And now having given a description of the beds at Guichen Bay, their structure and other features, as well as what I

consider to be portions of the same elsewhere, let me briefly describe the evidence they afford. We know that the land is rising at present, and we have fossiliferous rocks of the present period where the water has recently receded. These are our latest Australian tertiaries. Our earliest in South Australia are, as far as we know, the beds previously alluded to as Eocene. While these latter were forming, the land was sinking, and we obtain the knowledge of that fact by many reasons, such as the following I now give. Darwin has justly remarked that very thick fossiliferous beds are only formed during subsidence, and this is borne out by the thinness of the beds lately formed during a period of upheaval. The same illustrious geologist has proved that the whole bed of the Pacific is sinking, and that the subsidence is giving rise to coral islands far away from land. Now at this part of South Australia we have very thick beds, and those too of coral, which I have traced 100 miles inland without any break or sign of land during the epoch of their formation. I think there can be little question that the sea bed must have subsided where any great thickness of coral is found, because it will not live below 30 fathoms, and must soon have perished unless the lowering of the bottom kept pace with its building operations, or at all events would not give rise to thick strata, unless during subsidence. We have, then, evidence of subsidence and upheaval. Between these periods we find beds deposited from a deep sea current, which have afterwards been washed away, probably by the denudation they were exposed to during their uprising. I apprehend, therefore, the series of changes which have taken place to be somewhat in the following manner: the land was sinking slowly during the Eocene period, and the coral animal made up for the subsidence by its continual labours, just as it does now in the Pacific. Though this would prevent any very deep water being found on the site of the former land, yet the subsidence would, of course, remove the reef further and further away from the land, and render it more exposed to the action of the sea. Extensive changes in the relative position of the land would give rise to changes of temperature, and new ocean currents would be the result. Now the coral would not have stopped building as long as the animal could keep pace with the subsidence, but any current bearing sediment would kill it speedily. Darwin, and other voyagers, give many instances of this; but a stream of sediment, did, according to the evidence we have, break over the coral and

terminate its existence. This deposit was, therefore, stopped by a new one taking its place, which was of quite a different nature, being that which we find at Guichen Bay. How long after this the land continued to subside cannot be guessed, for we do not, and cannot, now know the extent of the beds formed subsequently. We see, however, that a change came at last, and upheaval followed, but so slow that coast action had time to remove successively, except in one or two places, all that the deep water current had thrown down, leaving only the dead coral exposed to view. All the facts given above bear out the correctness of these views, but of course I am far from claiming adhesion to them as perfectly certain. Indeed I have rather occasion to warn the Institute that neither my attainments nor habits of inquiry at all constitute me an infallible guide, and I shall consider myself fortunate if future and more experienced enquirers find nothing to correct in my theories. With regard to the nature of the rocks at Guichen Bay, I will just remark that though ocean currents generally seem to be clear water on the surface, they must carry sediment along the bottom, and that wherever soundings have been taken in them, the bottom has been found to consist of shells and fine sand. Sometimes, however, currents are found charged with sediment at the surface, such as those proceeding from the mouths of rivers, and then the water occasionally has a muddy tinge even at great distances from the coast.

I would extend this paper beyond reasonable limits, were I to give all the facts I have noticed connected with the subject. I will, therefore, conclude by calling attention to the vast operations of nature which are here disclosed. It is not alone the enormous subsidence which at first caused a deep coral reef and then an open sea (which must have maintained for ages to give rise to such a thickness of sedimentary rock), which must excite surprise. Nor is it the long period of upheaval. But the immense amount of denudation which has removed hundreds of square miles of thick beds of rock, is certainly a work of such magnitude as to excite wonder and amazement. At all events there is a fine agricultural country over the spot where such changes were operated, and the Mount Gambier volcano is a witness as to the cause which rescued land from sea. Many interesting questions remain to be asked, which can only be answered by very extended investigation. We might enquire whether the subsidence was very general in Australia. Also, whether the bed of the

Pacific, now submerged, was then a continent. If so, we might further ask, is its disappearance a compensation in the earth's crust for the extensive elevation we experience here? These enquiries may never be answered, but at least they let us know that there are more things in the earth than are accounted for in our present philosophy, and all the little facts we gain bring us nearer to that ocean shore where we gaze towards the boundless horizon of the omnipotence of that God who made these things which we pry into but cannot understand.

Art. XI.—*Description and System of Working of the Flagstaff Observatory.*—By Professor George Neumayer.

[With three Plates.]

[Read before the Institute, 20th October, 1858.]

When the first proposition was made by me to the Government of this colony to establish a Magnetic Observatory, I proposed to select, for the site of the same, a spot on the southern side of the Yarra. I made that selection because the geological formations were more favourable there than on this side of the river, and preliminary observations on the magnetic elements had established the superiority of that ground over any other round Melbourne; further, the business part of the city, being more remote, was not likely to cause disturbances and inconvenience; and, lastly, the greater vicinity of the harbour was well calculated to facilitate the communication with masters of ships—an important condition required for the entire success of the Observatory.

It was only after some hesitation on my part, and after having selected two other places near that originally proposed, that I followed the suggestion made to me by the Government, to investigate the suitability of the Flagstaff Hill, with a view to making it a site for the proposed Observatory, as the buildings within the enclosure of the late signal station would be available for that purpose. The fact that the Flagstaff Hill stands upon decomposed basalt, covered to depths from 10 to 20 feet with tertiary gravel, prompted me to be cautious, and a long series of preliminary observations, made within the enclosure and on the surrounding ground,